ELSEVIER

Preventive Veterinary Medicine 36 (1998) 287–305

PREVENTIVE VETERINARY MEDICINE

Feed-conversion ratio of finisher pigs in the USA

Williard C. Losinger*

USA Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Center for Epidemiology and Animal Health 555 South Howes Street, Suite 200, Fort Collins, Colorado, 80521, USA

Accepted 14 June 1998

Abstract

Although the feed-conversion ratio is recognized as a prominent indicator of profitability for pork producers, only 212 (50.7%) of 418 producers who were asked the feed-conversion ratio for finisher pigs provided a response during the USA National Animal Health Monitoring System 1995 National Swine Study. Of these, 126 (59.4%) producers furnished a feed-conversion ratio which they characterized as having been calculated from records, while 86 (40.6%) gave a response that they characterized as estimated or guessed. Feed-conversion ratios ranged from 2.18 to 5.91 kg of feed fed for each kg of live-body weight gained during the grower/finisher phase, with a mean of 3.28 and a standard deviation of 0.52. Stepwise regression revealed the following management factors to be associated with improved feed-conversion ratios: $\geq$3 different rations fed during the grower/finisher phase ($P<0.01$); no rations mixed on the farm ($P<0.05$); and not giving chlortetracycline in feed or water as a disease preventive or growth promotant ($P<0.01$). In addition, operations where $\geq$3000 pigs entered the grower/finisher-production phase during the six-month period prior to interview had a better mean feed-conversion ratio than operations where <3000 pigs entered the grower/finisher phase ($P<0.01$).

Keywords: Pig-feeding and nutrition; National study; NAHMS; Feed-conversion ratio; Feed efficiency; Mixed model

1. Introduction

Feed-conversion ratio (the ratio of feed disappearance to live weight gain) is an important determinant of profitability for swine producers (Edwards et al., 1989). Because feed costs represent approximately two-thirds of the total cost of pork

* Tel.: +1 970 490 7815; fax: +1 970 490 7899; e-mail: williard.c.losinger@usda.gov

PII: S0167-5877(98)00094-4

production, small increments in the feed-conversion ratio can have a major impact on the profitability of an operation. Therefore, improving the feed-conversion ratio is a major goal in pork production (Henry, 1992). Improvements in the feed-conversion ratio in recent years have been noted (Muirhead, 1989). Genetic selection (which has concentrated on increased growth and reduced fat) is an important factor that has had an impact on improving the feed-conversion ratio (Henry, 1992). Diet and use of antibiotics can influence the feed-conversion ratio in pigs (Henry, 1992; National Research Council, 1968; Tribble et al., 1956). Lopez et al. (1991) reported poorer feed-conversion ratios among cold-stressed pigs. Overcrowding of pigs may have a detrimental impact on the feed-conversion ratio (Brumm and Miller, 1996). In addition, some diseases can result in an inferior feed-conversion ratio in pigs (Muirhead, 1989; Straw et al., 1989).

Pork producers and those who serve their needs require a better understanding of factors that can influence the feed-conversion ratio in pigs. The objectives of this study were to examine feed-conversion ratios during the grower/finisher-production phase on operations in the USA, and to identify management and other factors that may be related to differences in feed-conversion ratios between operations.

2. Materials and methods

Data used in this study were collected during the USA National Animal Health Monitoring System (NAHMS) 1995 National Swine Study. The NAHMS is a relatively new program of the USA Department of Agriculture (USDA) (Bush and Gardner, 1995). Sixteen major pork-producing states that accounted for nearly 91% of 1 June, 1995 swine inventory and nearly 75% of USA-pork producers were included in the study (Losinger et al., 1997). In the first stage of data collection (which was completed in conjunction with the USDA's Quarterly Agriculture Survey from 1–23 June, 1995) National Agricultural Statistics Service (NASS) enumerators collected data from 1477 producers involved in all phases of swine production (farrowing, nursery, and grower/finisher) (USDA, 1995). Producers that participated in the first stage of data collection and that had $\geq$300 finisher pigs (with at least one pig$\geq$54 kg) on 1 June, 1995 were eligible to participate in the study's second stage, which concentrated on health and management practices in the grower/finisher-production phase (USDA, 1996). During the second stage of data collection, a federal or state veterinary medical officer (VMO) or animal-health technician (AHT) visited operations twice to administer questionnaires (once between 17 July and 13 September, 1995 and again between 6 November, 1995 and 17 January, 1996). In the final interview, producers were asked the feed-conversion ratio of pigs during the grower/finisher phase of production.

To screen potential explanatory variables, categorized variables from the survey questionnaires were added to a multivariable model that included region and a categorized variable based on the number of pigs that had entered the grower/finisher-production phase during the six months prior to the final visit by the VMO or AHT. Restricted maximum-likelihood (REML) estimation (Searle et al., 1992) was performed using the MIXED procedure of SAS (SAS Institute, Inc., 1992), with the feed-conversion ratio in the grower/finisher phase serving as the dependent variable. A variable which combined state and NASS-selection stratum (which was based on operation size and had availed in selecting the sample of operations for the study) was specified as a random effect. Variables with $P<0.3$ were considered to have passed the initial screening.

To examine relationships between potential explanatory variables and to obtain awareness of potential multicollinearity (Maddala, 1988), the CORR procedure of SAS (SAS Institute, Inc., 1990) was used to obtain Spearman rank correlation coefficients (Hogg and Craig, 1978) of the screened variables.

A multivariable model was developed using operations that provided responses to each of the screened variables. A forward-stepwise variable-selection technique was used (Maddala, 1988). Region, herd size (as determined by the number of pigs that had entered the grower/finisher phase of production during the six months prior to the final interview), quality of response to the question on feed-conversion ratio (whether reported by the farmer to have been calculated accurately or estimated/guessed), whether the operation had a farrowing facility, and average days in the grower/finisher unit were forced into the model. This was done to make certain that other explanatory variables did not enter the model merely because of management differences due to regional or herd-size effects, nor due to differences between farrow-to-finish and grower/finisher-only operations. In addition, the feed-conversion ratio may vary depending on the age and body weight of the pig. Therefore, average days in the grower/finisher unit was chosen as a proxy to account for the general effect of age and body weight on the overall feed-conversion ratio reported for the operation.

A separate model was formed for each screened variable by adding it to a model that included the forced variables (using the MIXED procedure of SAS, as described above). Schwarz's Bayesian Criterion (SBC) (Schwarz, 1978), provided by the MIXED procedure of SAS, was used to analyze each variable. The variable whose addition to the model resulted in the highest value for SBC was included in the model. Variable addition continued in a stepwise fashion until the maximum value for SBC was reached (i.e. the addition of no variable resulted in an increase in SBC).

3. Results

A total of 212 (50.7%) of 418 operations that participated in the second stage of data collection for the 1995 National Swine Study provided a feed-conversion ratio for pigs during the grower/finisher-production phase. In comparison, all study participants indicated whether they had a farrowing facility and what types of record-keeping systems they used. All but three participants indicated whether they used disease preventives and growth promotants in the feed or water. Similar to feed-conversion ratio, few respondents (235) reported average daily gain in the grower–finisher phase.

Table 1 summarizes the regional and herd-size distributions of the 212 operations that furnished the feed-conversion ratio. Responses ranged from 2.18 to 5.91 kg of feed disappearance during the grower/finisher phase for each kg of body weight gained (median 3.20; mean 3.28; SD 0.52) (Table 2).

Explanatory variables examined (including those 'ruled out' in the screening) are listed in Appendix A. The multivariable model appears in Table 3. Operations where $\geq$3000

Table 1
Number of operations that provided information on the feed-conversion ratio in the grower/finisher phase of production by region and number of pigs that entered the grower/finisher phase of production during the six months prior to the final interview in the United States National Animal Health Monitoring System 1995 National Swine Study

	Pigs that entered grower/finisher unit, no.						Total
	<800		800–2999		≥3000		
	No.	%	No.	%	No.	%	
Region							
Southeast	5	13.5	13	35.1	19	51.4	37
North	16	34.8	18	39.1	12	26.1	46
Midwest	29	22.5	52	40.3	48	37.2	129
Total	50	23.6	83	39.2	79	37.3	212

States included in each region were: Southeast: Georgia, Kentucky, Missouri, North Carolina, and Tennessee; North: Indiana, Michigan, Ohio, Pennsylvania and Wisconsin; Midwest: Illinois, Iowa, Kansas, Minnesota, Nebraska, and South Dakota.

Table 2
Number of operations by reported feed-conversion ratio (kg of feed disappearance for each kg gained) during the grower/finisher phase. Based on 212 respondents in the United States National Animal Health Monitoring System 1995 National Swine Study

Range of feed conversion ratio	Number of operations	Percent of operations
<3.0	36	17.0
≥3.0, <3.1	61	28.8
≥3.1, <3.2	33	15.6
≥3.2, <3.5	36	17.0
≥3.5, <4.0	30	14.2
≥4.0	16	7.5
	212	100.0

pigs entered the grower/finisher-production phase during the six-month period prior to the final interview had a better mean feed-conversion ratio than operations where <3000 pigs entered the grower/finisher phase. In addition, the model demonstrated the following management practices to be associated with improved feed conversion ratios: ≥3 different rations fed during the grower/finisher phase; no rations mixed on the farm; and not giving chlortetracycline in feed or water as a disease preventive or growth promotant. Table 4 shows that the non-forced explanatory variables were not highly correlated with each other.

4. Discussion

The data in the NAHMS 1995 National Swine Study were from randomly selected operations representing ≈90% of the swine inventory in the USA (USDA, 1995). Prior to the NAHMS, a weakness of many livestock studies in the USA was that they were often

Table 3
Least-squares means of feed-conversion ratio (kg of feed disappearance per kg of gain) for finisher pigs by farm-level variables. All variables listed were included in the model. The model is based on 194 operations that provided data for all screened variables in the United States National Animal Health Monitoring System 1995 National Swine Study

Variable/response	Least-squares mean	SE	P>F
Region (forced into model)			0.86
Southeast (n=30)	3.41 [a]	0.14	
North (n=41)	3.35 [a]	0.14	
Midwest (n=123)	3.36 [a]	0.10	
Number of pigs that entered grower/finisher unit in six months prior to interview (forced into model)			<0.01
<800 (n=49)	3.52 [b]	0.13	
800 to 2999 (n=78)	3.39 [b]	0.12	
≥3000 (n=67)	3.21 [a]	0.11	
Quality of response to feed conversion ratio (forced into model)			0.13
Calculated accurately (n=114)	3.48 [a]	0.11	
Estimated/guessed (n=80)	3.32 [a]	0.12	
Farrowing facility present (forced into model)			
Yes (n=170)	3.45 [a]	0.11	0.09
No (n=34)	3.30 [a]	0.13	
Average days in grower/finisher unit (forced into model)			0.18
<120 days (n=124)	3.33 [a]	0.12	
≥120 days (n=70)	3.42 [a]	0.12	
Average number of different types of rations fed to pigs during grower/finisher phase			<0.01
<3 (n=89)	3.48 [b]	0.12	
≥3 (n=105)	3.26 [a]	0.12	
Any rations mixed on farm			0.05
Yes (n=137)	3.45 [b]	0.11	
No (n=57)	3.30 [a]	0.12	
Chlortetracycline given to finisher pigs in feed or water as a preventive or growth-promotant			<0.01
Yes (n=80)	3.48 [b]	0.12	
No (n=114)	3.27 [a]	0.12	

[a,b] Least-square means (for levels within a variable) with different superscripts differ (P<0.05).

limited to research farms or a few operations; operations were seldom selected to permit inferences to be drawn to larger populations (King, 1990; Bush and Gardner, 1995).

The results of the present analysis do not necessarily apply either to smaller operations or to states not included in the study because the second stage of data collection for the 1995 National Swine Study was restricted to operations with ≥300 finisher pigs

Table 4
Spearman rank correlation coefficients for non-forced explanatory variables associated with feed-conversion ratio in the final model

	Any rations mixed on farm	Chlortetracycline given to finisher pigs in feed or water as a preventive or growth-promotant
Average number of different types of rations fed to pigs during grower/finisher phase	0.06 (0.40)	0.06 (0.41)
Any rations mixed on farm		0.16 (0.02)

Figures in parentheses represent P under H_0:|ρ|=0.

Although this study found statistically significant associations between certain management practices and the feed-conversion ratio, this does not necessarily mean that these management practices were the cause of differences in feed-conversion ratios. The associations found here represent possible areas where attention by pork producers or continued research by investigators could be beneficial. In addition, one would need to consider the costs connected with measures aimed at improving the feed-conversion ratio to determine the net impact on profitability (Heady and Dillon, 1961).

Twenty-eight potential risk factors were offered to the multivariable model; at a 5% alpha, one or two might be expected to be significant just due to chance. However, I believe that those significant are biologically reasonable because they relate to feeding practices which affect the feed-conversion ratio.

No information on the genetic qualities of finisher pigs was collected in the 1995 National Swine Study. Selection for efficient, rapid lean growth is a major goal of pig breeders, and feed-conversion ratio varies according to genotype (Gu et al., 1991). It is increasingly common for genetics and breeding companies to arrange exclusive contracts for breeding stock with particular pork producers (Honeyman, 1996). Identifying specific breeds or genotypes of pigs was beyond the scope of this study

Although the feed-conversion ratio is widely regarded as an important determinant of a pork producer's profitability, the outcome of this national study was biased by the fact that only about one-half of the participating producers provided a feed-conversion ratio. Moreover, fewer than one-half of producers who reported a feed-conversion ratio provided a figure that was reported to have been calculated from records rather than estimated or guessed. Advantages of on-farm data bases and knowledge-based analysis programs to livestock producers have been well documented (Muirhead, 1976; Spahr, 1993). The results of the present study suggest that the USA-pork industry has considerable room for improvement in terms of producers keeping and using careful records on a key parameter (i.e. feed-conversion ratio) that affects productivity.

In any sample survey, non-sampling error is inevitable (Sukhatme and Sukhatme, 1970). Although the difference in mean feed-conversion ratio between operations that calculated the feed-conversion ratio accurately and operations that estimated or guessed the feed-conversion ratio was not statistically significant (Table 3), forcing this variable into the model was important to account for its impact on other model variables (Maddala, 1988).

One limitation of this study is that only an overall figure for the feed-conversion ratio in the grower/finisher-production phase was requested. Efficiency of feed conversion can differ depending on gender, age and body weight (Cromwell et al., 1993; Wise et al., 1996). Furthermore, no information was collected on start and end weights of finisher pigs. Since days in the grower/finisher unit (which was forced into the model), age at entering and age at leaving the grower/finisher unit were examined but did not have significant impacts on the overall feed-conversion ratio, one probably need not be overly concerned about the impact of biases resulting from different operations having dissimilar feed-conversion ratios due to keeping pigs in the grower/finisher unit at disparate periods of their lives. No data were gathered on gender-specific feed-conversion ratios, nor on the number of finisher pigs by sex. Although split-sex feeding did not pass the screening phase of analysis, some bias could be unmitigated if some operations specialized in finishing one gender over another. Moreover, inconsistencies could have occurred depending on whether or not the weights of dead pigs were included in the live-weight gains. Although producers should have measured output as saleable product (and not included the weights of pigs that died), the possibility exists that some producers may have included the weights of pigs that died in their calculations.

In the USA, an increasing proportion of pigs are raised on large, intensive operations (Honeyman, 1996). The problem of manure disposal can intensify on large operations, particularly where manure is not valued as an organic fertilizer for crop production (Hoag and Roka, 1995; Westenbarger and Letson, 1995). Excessive nitrogen and phosphorus in pig waste represent a particular concern (Biehn and Baker, 1996). Since the quantity of manure (and amount of nitrogen and phosphorus) excreted can be controlled through diet modification (Biehn and Baker, 1996; Council for Agricultural Science and Technology, 1996), converting feed into body weight more efficiently could be more important for many larger producers that need to limit the amount of waste produced. In addition, the better feed-conversion ratio observed for larger operations could be a reflection of a superior genetic potential for pigs acquired by large operations (Honeyman, 1996).

Another limitation of this study is that no information on the formulation of diets was collected. In the USA, the diet of finisher pigs consists predominantly of a maize/soybean meal combination, which has a relatively narrow range of energy values (National Research Council, 1968). The composition of the diet has an impact on the feed-conversion ratio among finisher pigs (Henry, 1992). Nutrient requirements of finisher pigs do vary based on body weight (National Research Council, 1968). Diets limited to maize and soybean meal may not contain enough Vitamin E to meet the pigs' needs (Anderson et al., 1995). In addition, more than one-half of the phosphorus in maize and soybean meal is in the form of phytate, which is poorly available to pigs (Lei et al., 1993). Deficiency in essential nutrients (such as tryptophan) can have a negative impact on growth performance (Henry et al., 1996). Amino-acid requirements change with age and body weight (Coma et al., 1995; Hahn and Baker, 1995). Therefore, operations that fed three or more different types of rations to their pigs may have been paying closer attention to the pigs' nutritional needs, and were rewarded with an improved feed-conversion ratio. For operations that fed >1 ration, most operations reported that body weight was the primary trigger for progressing from one ration to the next (USDA, 1996).

Operations that did not mix their own rations may have incurred a higher cash expense per quantity of feed fed than operations that grew and mixed their own rations, and therefore may have been forced to pay greater attention to improving the feed-conversion ratio.

Subtherapeutic levels of antibiotics have long been used as growth promotants in the diets of pigs (Hathaway et al., 1996). The 1995 National Swine Study revealed that 91.3±2.0% of grower/finisher producers gave antibiotics or other agents as a disease preventive or growth promotant in the feed, and 3.2±1.4% in the water (USDA, 1996). Chlortetracycline was given in feed by 41.1±4.0% of grower/finisher producers (USDA, 1996). Chlortetracycline increases the rate of growth of pigs – possibly through mechanisms that include the suppression of intestinal pathogens (Visek, 1978).

Some debate has existed over whether the low levels of tetracyclines used for growth-promotion purposes in pigs and other livestock may have selected for tetracycline-resistant bacteria (Chopra et al., 1981). Dawson et al. (1984) and Langlois et al. (1984) identified antibiotic-resistant bacteria from pigs fed subtherapeutic and therapeutic levels of chlortetracycline. Sarmiento and Moon (1988) reported that oxytetracycline-treated pigs inoculated with an enterotoxigenic strain of *Escherichia coli* gained weight more slowly than non-treated pigs following recover, while oxytetracycline-treated controls gained weight faster than non-treated controls. Therefore, producers who feed tetracyclines to enhance growth may need to be careful to exclude pathogens from their operations.

In a controlled experiment, Tribble et al. (1956) reported increased gain and an improved feed-conversion ratio in pigs fed chlortetracycline from weaning to 45 kg – but no differences in gain or the feed-conversion ratio between pigs fed chlortetracycline and pigs not fed chlortetracycline in pigs >45 kg. Hathaway et al. (1996) found that a diet supplemented with 22.7 ppm of chlortetracycline, 22.7 ppm of sulfamethazine, and 11.4 ppm of penicillin resulted in an improved feed-conversion ratio for pigs from weaning (at 34 days of age) over a five-week period. In some cases, diet supplementation with antibiotics may result in increased feed intake and average daily gain without necessarily improving the feed-conversion ratio (Henry, 1992). Further research will be required to determine why the association between feeding chlortetracycline and poorer feed-conversion ratio was observed. In addition, conditions experienced by pigs within specific production unit may not exactly mirror the situation of pigs in controlled-research settings. Therefore, individual producers may wish to perform trials to determine whether the feed additives that they use have the desired impact on body-weight gain and the feed-conversion ratio.

5. Conclusions and implications

Although the feed-conversion ratio is considered by many to play a central role in determining a pork producer's profitability, the results of the NAHMS 1995 National Swine Study showed that a lot of producers in the USA did not know the feed-conversion ratio of their finisher pigs. As the industry becomes more competitive, more pork producers will need to pay closer attention to feed-conversion ratios and to factors that influence the feed-conversion ratio on their operations. Larger operations (where at least 3000 pigs entered the grower/finisher phase over a six-month period) had the advantage of a significantly better mean feed-conversion ratio than smaller operations.

Superior feed-conversion ratios were linked to feeding more than two different kinds of rations during the grower/finisher phase and not mixing rations on the operation. More research will be needed to examine the relationship between chlortetracycline and the feed-conversion ratio on farms in the USA.

Appendix A

Explanatory variables considered for inclusion in the multivariable model with feed-conversion ratio (kg of feed disappeared per kg of body weight gain) as the dependent variable. Also listed are the sample sizes and the percent of the sample reporting at or above the sample median feed-conversion ratio of 3.2 kg of feed disappeared per kg of body weight gain.

	Number in sample	Percent at or above median feed-conversion ratio
Variables forced into the model		
Region		
Southeast	37	32.4
North	46	32.6
Midwest	129	42.6
Number of pigs that entered grower/finisher unit in six months prior to interview		
<800	50	60.0
800 to 2999	83	42.2
≥3000	79	21.5
Reported quality of response to feed-conversion ratio		
Calculated accurately	126	34.1
Estimated/guessed	86	45.4
Farrowing facility present		
Yes	178	39.9
No	34	32.4
Average days in grower/finisher facility		
<120 days	132	34.9
≥120 days	73	46.6

Variables with $P<0.3$ and offered to multivariate model		
Average number of different types of rations fed to pigs during grower/finisher phase		
<3	94	44.7
≥ 3	117	33.3
Any rations mixed on farm		
Yes	144	45.1
No	67	31.8
Chlortetracycline given as preventive or growth-promotant in feed or water		
Yes	85	49.4
No	125	31.2
Average weaning age		
<20 days	49	30.6
20 to 27 days	80	40.0
>27 days	48	50.0
No farrowing facility	34	32.4
Bulk bins		
No bulk bins or all bulk bins dedicated to one ration only	76	43.4
Different rations in same bulk bins	136	36.0
Cleaning of feeders		
Rarely or never cleaned	45	53.3
Cleaned at least sometimes	166	34.3
Frequency of treating individual sick pigs and leaving in existing pen		
Never or sometimes	76	36.8
Most of time or always	136	39.7
Percent of finisher pigs culled in last six months		
$<1\%$	102	38.2
$\geq 1\%$	105	41.0
Importance of length of time on feed or age in deciding when to send pigs to market		
Not, slight or moderate	157	41.4
Very or extreme	55	30.9

Importance of needing space for incoming pigs in deciding when to send pigs to market		
Not, slight or moderate	131	42.8
Very or extreme	81	32.1
Frequency of marketing all but a few pigs in pen or building, keeping some back for additional feeding		
Never or sometimes	134	36.3
Most of time of always	78	41.0
Regularly give finisher pigs antibiotics in feed for preventive purposes		
Yes	175	37.1
No	34	50.5
Regularly give finisher pigs any antibiotic for preventive purposes		
Yes	186	37.6
No	25	48.0
Operation is a contract producer		
Yes	17	0.0
No	195	42.1
Use a pocket-diary or calendar for keeping records		
Yes	104	37.5
No	108	39.8
Use service bureau-based record keeping system		
Yes	63	38.1
No	149	38.9
Feral pigs considered a health threat to swine operation		
Yes	21	28.6
No	191	39.8
Feral pigs considered a health threat to swine operation		
Yes	21	28.6
No	191	39.8

Regularly vaccinate for *Escherichia coli* scours		
Yes	130	42.3
No	82	32.9
Regularly vaccinate for Parvovirus		
Yes	167	40.1
No	45	33.3
Regularly vaccinate for leptospirosis		
Yes	172	39.5
No	40	35.0
Tested nutrient content of manure in 12 months prior to interview		
Yes	89	25.8
No	112	49.1
Any finisher pigs on concrete slats only		
Yes	114	27.2
No	97	51.6
Below-floor slurry or deep-pit waste-management system used		
Yes	134	35.8
No	78	43.6
Trucks and trailer used for transporting livestock allowed to cross perimeter of operation		
Yes	158	40.5
No	54	33.3
Any finisher pigs culled for respiratory problems in last six months		
Yes	79	36.7
No	128	40.6
Any finisher pig deaths due to trauma in last six months		
Yes	75	36.0
No	131	41.2
Any finisher pig deaths due to respiratory problems in last six months		
Yes	164	39.6
No	42	38.1
Variables with $P \geq 0.3$ (no longer considered)		

All-in all-out versus continuous management		
All-in all-out	116	32.8
Continuous	92	46.7
Average age at leaving nursery		
≤60 days	67	41.8
>60 days	100	36.0
Average age at leaving grower/finisher unit		
<180 days	95	32.6
≥180 days	111	44.1
Frequency of separating or quarantining new arrivals of feeder pigs		
Always or no new arrivals	147	37.4
Sometimes or never	49	44.9
Frequency of testing health of new arrivals of feeder pigs by collecting blood or fecal specimens		
Always or no new arrivals	133	37.6
Sometimes or never	73	42.5
Frequency of treating individual sick pigs and removing to a sick pen		
Never or sometimes	186	40.3
Most of time or always	26	26.9
Death rate in grower/finisher phase in last six months		
<2%	102	38.2
2 to 4%	83	36.1
>4%	22	59.1
Importance of market price in deciding when to send pigs to market		
Not, slight or moderate	173	38.2
Very or extreme	39	41.0
Importance of weight in deciding when to send pigs to market		
Not, slight, moderate, very	106	39.6
Extreme	106	37.7

Frequency of assembling a uniform group based on weight for sending pigs to slaughter in last six months		
Never/sometimes/most of time	82	37.8
Always	130	39.2
Frequency of assembling a uniform group based on sex for sending pigs to slaughter in last six months		
Never	100	42.0
Sometimes to always	112	35.7
Average Daily Gain		
<0.75 kg/pig/day	124	40.3
≥ 0.75 kg/pig/day	72	27.8
Not reported	16	75.0
Reported quality of response to average daily gain		
Calculated accurately	117	35.9
Estimated/guessed	79	35.4
Not reported	16	75.0
Total confinement		
Yes	145	35.2
No	64	46.9
Finisher pigs have outside access		
Yes	44	52.3
No	165	35.2
Pit-holding waste-management system		
Yes	96	34.4
No	113	42.5
Regularly deworm finisher pigs for preventive purposes		
Yes	95	42.1
No	113	37.2
Regularly give finisher pigs mange/lice treatment for preventive purposes		
Yes	58	41.4
No	144	37.5

Regularly give finisher pigs antibiotics in water for preventive purposes		
Yes	49	36.7
No	159	39.6
Use home-computer-based-record-keeping system		
Yes	93	36.6
No	119	40.3
Entry to premises restricted to employees only		
Yes	127	33.9
No	85	45.9
Regularly vaccinate for procine reproductive and respiratory syndrome		
Yes	95	32.6
No	117	43.6
Regularly vaccinate for erysipelas		
Yes	171	38.0
No	41	41.5
Used a veterinarian from 1 Dec, 1994 through 31 May, 1995 for any purpose		
Yes	188	38.8
No	24	37.5
Tested ground water in 12 months prior to interview		
Yes	88	38.6
No	113	38.9
Tested air quality in 12 months prior to interview		
Yes	62	30.7
No	135	43.0
Split-sex feeding		
Yes	94	30.9
No	109	44.0
Antibiotics or other agents given as disease-preventive or growth-promotant in feed or water		
Yes	189	38.6
No	21	38.1

Carbadox given as preventive or growth-promotant in feed or water		
Yes	26	53.9
No	184	36.4
Oxytetracycline given as preventive or growth-promotant in feed or water		
Yes	19	47.4
No	191	37.7
Tylosin given as preventive or growth-promotant in feed or water		
Yes	86	29.1
No	124	45.2
Bacitracin given as preventive or growth-promotant in feed or water		
Yes	100	41.0
No	110	36.4
Any finisher pigs on partial slats		
Yes	90	41.1
No	121	36.4
Any finisher pigs on solid concrete only		
Yes	97	49.5
No	114	29.0
Porcine reproductive and respiratory syndrome diagnosed in finisher pigs by veterinarian or laboratory in last 12 months		
Yes	79	29.1
No	133	44.4
Salmonella diagnosed in finisher pigs by veterinarian or laboratory in last 12 months		
Yes	30	33.3
No	182	39.6
Haemophilus diagnosed in finisher pigs by veterinarian or laboratory in last 12 months		
Yes	46	41.3
No	166	38.0

All finisher pigs came from on-site farrowing units belonging to the operation		
Yes	135	40.7
No	77	35.1
All finisher pigs came from farrowing units belonging to the operation (either on-site or off-site)		
Yes	182	36.3
No	30	53.3
Any finisher pigs culled for digestive problems in last six months		
Yes	47	36.2
No	160	40.0
Any finisher pigs culled for lameness in last six months		
Yes	107	36.5
No	100	42.0
Any finisher pig deaths due to scours in last six months		
Yes	43	44.2
No	163	38.0
Any finisher pig deaths to lameness in last six months		
Yes	121	37.2
No	85	42.4
Any finisher pigs housed in a building with a single bulk bin to the building		
Yes	75	46.7
No	133	35.3
Any finisher pigs housed in a building with multiple bulk bins to the building		
Yes	129	31.8
No	79	51.9
Any finisher pigs housed in a building or outside with a grinder or mixer directly to feeders		
Yes	70	57.1
No	138	30.4

Any pigs marketed for slaughter in the last six months with a herd type identification applied to the operation		
Yes	37	40.5
No	175	38.3

References

Anderson, L.E., Myer, R.O., Brendemuhl, J.H., McDowell, L.R., 1995. Bioavailability of various vitamin E compounds for finishing swine. J. Anim. Sci. 73, 490–495.

Biehn, R.R., Baker, D.H., 1996. Efficacy of supplemental 1 alpha-hydroxycholecalciferol and microbial phytase for young pigs fed phosphorus or animo acid-deficient corn-soybean meal diets. J. Anim. Sci. 74, 2960–2966.

Brumm, M.C., Miller, P.S., 1996. Response of pigs to space allocation and diets varying in nutrient density. J. Anim. Sci. 74, 2730–2737.

Bush, E.J., Gardner, I.A., 1995. Animal health surveillance in the United States via the National Animal Health Monitoring System (NAHMS). Epidém. et Santé Anim. 27, 113–126.

Chopra, I., Howe, T.G.B., Linton, A.H., Linton, K.B., Rochmond, M.H., Speller, D.C.E., 1981. The tetracyclines: prospects at the beginning of the 1980s. J. Antimicrob. Chemother. 8, 5–21.

Coma, J., Carrion, D., Zimmerman, D.R., 1995. Use of plasma urea nitrogen as a rapid response criterion to determine the lysine requirements of pigs. J. Anim. Sci. 73, 472–481.

Council for Agricultural Science and Technology, 1996. Integrated Animal Waste Management. Task Force Report No. 128. Center for Agricultural Science and Technology, 4420 West Lincon Way, Ames, IA 50014 USA, p. 87.

Cromwell, G.L., Cline, T.R., Crenshaw, J.D., Crenshaw, T.D., Ewan, R.C., Hamilton, C.R., Lewis, A.J., Mahan, D.C., Miller, E.R., Pettigrew, J.E., Tribble, L.F., Veum, T.L., 1993. The dietary protein and(or) lysine requirements of barrows and gilts. J. Anim. Sci. 71, 1510–1519.

Dawson, K.A., Langlois, B.E., Stahly, T.S., Cromwell, G.L., 1984. Antibiotic resistance in anaerobic and coliform bacteria from the intestinal tract of swine fed therapeutic and subtherapeutic concentrations of chlortetracycline. J. Anim. Sci. 58, 123–131.

Edwards, W.M., van der Sluis, G.T., Stevermer, E.J., 1989. Determinants of profitability in farrow-to-finish swine production. North Central J. Agr. Econ. 11(1), 17–25.

Gu, Y., Schinckel, A.P., Forrest., J.C., Kuei, C.H., Watkins, L.E., 1991. Effects of ractopamine, genotype, and growth phase on finishing performance and carcass balue in swine. II Estimation of lean growth rate and lean feed efficiency. J. Anim. Sci. 69, 2694–2702.

Hahn, J.D., Baker, D.H., 1995. Optimum ratio to lysine of threonine, tryptophan, and sulfur amino acids for finishing swine. J. Anim. Sci. 73, 482–492.

Hathaway, M.R., Dayton, W.R., White, M.E., Henderson, T.L., Henningson, T.B., 1996. Serum insulin-like growth factor I (IGF-I) concentrations are increased in pigs fed microbials. J. Anim. Sci. 74, 1541–1547.

Heady, E.O., Dillon, J.L., 1961. Agricultural Production Functions. Iowa State University Press, Ames, IA, p. 667.

Henry, Y., 1992. Influence of diet composition on feed efficiency and utilisation in growing-finishing pigs. World Rev. Anim. Prod. 27, 76–92.

Henry, Y., Séve, B., Mounier, A., Ganier, P., 1996. Growth performance and brain neurotransmitters in pigs as affected by tryptophan, protein and sex. J. Anim. Sci. 74, 2700–2710.

Hoag, D.L., Roka, F.M., 1995. Environmental policy and swine manure management: waste not or want not? Am. J. Alt. Agr. 10, 163–166.

Hogg, R.V., Craig, A.T., 1978. Introduction to Mathematical Statistics, Fourth Edition. MacMillan Publishing Company, Inc., New York, p. 438.

Honeyman, M.S., 1996. Sustainability issues of U.S. swine production. J. Anim. Sci. 74, 1410–1417.

King, L.J., 1990. The National Animal Health Monitoring System: fulfilling a commitment. Prev. Vet. Med. 8, 89–95.

Langlois, B.E., Dawson, K.A., Stahly, T.S., Cromwell, G.L., 1984. Antibiotic resistance of fecal coliforms from swine fed subtherapeutic and therapeutic levels of chlortetracycline. J. Anim. Sci. 58, 666–674.

Lei, X.G., Ku, P.K., Miller, E.R., Yokoyama, M.T., 1993. Supplementing corn-soybean meal diets with microbial phytase linearly improves phytate phosphorus utilization by weanling pigs. J. Anim. Sci. 71, 3359–3367.

Lopez, J., Jesse, G.W., Becker, B.A., Ellersieck, M.R., 1991. Effects of temperature in the performance of finishing swine: II. Effects of a cold, diurnal temperature on average daily gain, feed intake, and feed efficiency. J. Anim. Sci. 69, 1850–1855.

Losinger, W.C., Bush, E.J., Hill, G.W., Smith, M.A., Garber, L.P., Rodriguez, J.M., Kane, G., 1997. Design and implementation of the United States National Animal Health Monitoring System 1995 National Swine Study. Prev. Vet. Med., in press.

Maddala, G.S., 1988. Introduction to Econometrics. Macmillan Publishing company, New York, p. 472.

Muirhead, M.R., 1976. Veterinary problems of intensive pig husbandry. Vet. Rec. 99, 288–292.

Muirhead, M.R., 1989. Factors affecting efficient growth rate in the feeding pig. Vet. Ann. 29, 103–109.

National Research Council., 1968. Nutrient Requirements of Domestic Animals Number 2: Nutrient Requirements of Swine, Sixth Edition. Publication 1599. National Academy of Sciences, Washington, D.C., p. 69.

Sarmiento, J.I., Moon, H.W., 1988. Postweaning diarrhea in swine: effects of oxytetracycline on enterotoxigenic *Escherichia coli* infection. Am. J. Vet. Res. 49, 1160–1163.

SAS Institute, Inc., 1990. SAS® Procedures Guide, Version 6, Third Edition. SAS Institute, Inc., Cary, NC, p. 705.

SAS Institute, Inc., 1992. SAS® Technical Report P-229, SAS/STAT® Software: Changes and Enhancements, Release 6.07. SAS Institute, Inc., Cary, NC, p. 620.

Schwarz, G., 1978. Estimating the dimension of a model. The Annals of Statistics 6, 461–464.

Searle, S.R., Casella, G., McCulloch, C.E., 1992. Variance Components. John Wiley and Sons, Inc., New York, p. 501.

Spahr, S.L., 1993. New technologies and decision making in high producing herds. J. Dairy Sci. 76, 3269–3277.

Straw, B.E., Tuovinen, V.K., Bigras-Poulin, M., 1989. Estimation of the cost of pneumonia in swine herds. J. Am. Vet. Med. Assoc. 195, 1702–1706.

Sukhatme, P.V., Sukhatme, B.V., 1970. Sampling Theory of Surveys with Applications. Iowa State University Press, Ames, IA, p. 452.

Tribble, L.F., Pfander, W.H., Lasley, J.F., Zobrisky, S.E., Brady, D.E., 1956. Factors affecting growth, feed efficiency and carcass in swine. Agricultural Experiment Station, College of Agriculture. University of Missouri Research Bulletin 609, 46.

United States Department of Agriculture., 1995. Swine ‘95 Part I: Reference of 1995 Swine Management Practices. Publication N186.995. USDA:APHIS:VS, CEAH, 555 South Howes Street, Fort Collins, CO 80521 USA, p. 22.

United States Department of Agriculture., 1996. Swine ‘95 Grower/Finisher Part II: Reference of 1995 U.S. Grower/Finisher Health and Management Practices. Publication N201.696. USDA:APHIS:VS, CEAH, 555 South Howes Street, Fort Collins, CO 80521 USA, p. 24.

Visek, W.J., 1978. The mode of growth promotion of antibiotics. J. Anim. Sci. 46, 1447–1469.

Westenbarger, D.A., Letson, D., 1995. Livestock and poultry waste control costs. Choices, Second Quarter, pp. 27–30.

Wise, T., Klindt, J., Lunstra, D.D., Buonomo, F.C., Yen, J.T., 1996. Thymic, gonadal, and endocrine relationships in gilts and boars administered porcine somatotropin. J. Anim. Sci. 74, 2992–3000.